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ABSTRACT

Preparing students for transfer to four-year colleges remains a significant part of the mission of most community college mathematicians. For some 30 years, calculus has been synonymous with entry-level college mathematics. Recent educational and technological changes, however, demand that the definition of college-level work in mathematics be expanded to include college algebra/elementary functions, and finite mathematics, as well as calculus, introductory linear algebra, and differential equations. Freshman and sophomore mathematics offerings can be improved through revision and incorporation, rather than wholesale change. An emphasis should be placed on teaching students to apply theorems rather than to prove them, and preference should be given to discrete mathematics topics over complex continuous topics. Discrete math topics can be accommodated through, for example, the use of tools such as the computer, the reincorporation of simple counting and probability in college algebra courses, and linear programming. Other ways in which the mathematics curriculum can be improved are through the development of liberal arts math courses and through increased attention to communication skills in math classes. In order for these curricular revisions to be effective, they must be initiated by an informed faculty, rather than imposed upon them; therefore, continuing education of faculty may be the most important ingredient in effecting meaningful curriculum revision. (Author/LAL)

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SUMMARY

LET'S KEEP THE COLLEGE IN OUR COMMUNITY COLLEGES
(Mathematics for College Transfer)

Larry Curnutt

Preparing students for transfer to four-year schools remains a significant part of the mission of most community college mathematicians. Freshman and sophomore mathematics offerings can be improved by including topics from discrete mathematics; this ought to be accomplished through revision and incorporation rather than wholesale change. Students of all majors can benefit from mathematics at the college level, and appropriate "liberal arts math" courses should be available for them. For the sake of mathematics and our students we should pay more attention to communication skills in mathematics classes. Continuing education of faculty may be the most important ingredient in effecting meaningful curriculum revision.

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Sloan Foundation Conference on New Directions in Two-Year College Mathematics
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LET'S KEEP THE "COLLEGE" IN OUR COMMUNITY COLLEGES
(Mathematics for College Transfer)

Larry Curnutt

More than twenty years have passed since I first stepped onto the campus of my hometown's community college. (They were called "junior" colleges in those days.) At the time, even though all of my rather vague career goals required baccalaureate degrees, I chose to attend a community college for financial reasons. Many of my classmates were in the same boat. Few of us had the luxury of worrying about the quality of the education we sought.

ENTRY LEVEL COLLEGE MATHEMATICS: AUDIENCE AND DEFINITION

Today's community college students comprise a much larger and more heterogeneous lot, and their reasons for attending a community college are often much more imaginative. Yet, despite the rich variety of two-year vocational programs available to them, the overwhelming majority of students who enroll in my community college mathematics courses (even at the elementary and intermediate algebra levels) still declare that transferring to a four-year school is their immediate objective. Fortunately, they study from better textbooks today, and, in general, their instructors are more extensively educated than they were in 1962. Staffed by educators who have consciously chosen to concentrate on the first two years of college (as opposed to "graduating" from the high school ranks or "dropping-out" of the research arena), community colleges are better equipped than ever to prepare university-bound students.

Exactly what constitutes appropriate preparation for college level work in mathematics, of course, depends on our definition of "college level mathematics." For some thirty years this issue has remained essentially static, for calculus has been synonymous with entry level

college mathematics. (Elementary functions and finite math courses may have been available and even earned credit in the universities, but the attention paid to them and the status accorded them has been nominal in comparison to calculus.) However, the last three or four years have seen encroachment from two directions on calculus' predominance. First, most universities now admit that even some of their mathematics majors need to postpone calculus until their sophomore years [1], while users of mathematics require more and more access to all pre-calculus courses. Secondly, as computers have grown more accessible and computing more generally important, discrete mathematics has begun to find its natural (?) place in the curriculum. Some mathematician-educators (eg. Tucker and Lucas in [6]) have argued that a yearlong course in discrete mathematics should replace calculus for many students, majors and users alike. Since mathematization in many nontraditional disciplines seems inexorable, growth in the demand for post-high school precalculus mathematics in the lower division curriculum is inevitible (though I doubt that it will happen as dramatically as Tucker and Lucas propose). Thus, any reasonable definition of "college level mathematics" ought to include college algebra/elementary functions and finite mathematics, as well as calculus, introductory linear algebra and differential equations.

IMPROVEMENTS IN THE FIRST TWO YEARS OF COLLEGE MATHEMATICS

How should we in the community colleges meet this expanding, broadening audience in our courses? Our credibility with the universities hinges on the answer. A pertinent and unifying tenet bears repeating here: the thrust of freshman and sophomore mathematics courses should be to apply theorems rather than to prove them. (Yes, community college mathematicians have to exercise willful restraint in this area.) In deciding whether to include a particular piece of mathematics in a course, all of us who teach freshman/sophomore level mathematics should ask ourselves, "Is there a quick payoff for the students?" Usually, answers such as "Yes, in quantum mechanics." or "Sure, this will allow us to state the Fundamental Theorem of Algebra completely." must be discounted, respectively, as too distant and too incestuous to be compelling to our students. For example, do you teach DeMoivre's Theorem in your precalculus courses? How much time do you

devote to complex numbers in your sequence of intermediate algebra, college algebra and elementary functions courses? More than enough, I suspect; they're in all the textbooks. At the risk of me learning something, I implore you to present just one genuine application, meaningful to lower division students, in which it is essential or illuminating to know that the roots of $x \pm bx + c = 0$ are $r \pm r\,i$ rather than just that the roots are not real. I do not advocate that we banish complex numbers (some of my favorite eigenvalues are complex!), only that here is a place where we might buy some time for topics that are more relevant to the mathematics users in our classes who will not pursue mathematics beyond the calculus level. At a slightly higher level the same simple test can be applied to the formal definition of "limit" with similar results. Surely, no one will question the wealth of interesting mathematics and applications that can be managed with a sound heuristic understanding of the limit concept. Pedagogically, slogging through a few arguments will not increase the chances that limits will be used correctly or effectively. (Toward this end, consult [4] for a productive alternative.) Be sure, this is not a plea for training better polynomial differentiators in the community colleges; we cannot afford that image.

Although these examples suggest that there is plenty of room for improvement, I believe that the structure and implementation of the community college mathematics curriculum is basically solid. And why shouldn't it be? We've been practicing it for a long time; we've gotten good at it; and it does what it's designed to do -- to prepare students who are competent to do as well in schools of engineering, business, etc. as their university-trained classmates. However, community colleges have done no better job promoting discrete mathematics than most of the rest of the academic community. Perhaps we should all subscribe to an "affirmative action" plan that favors hiring mathematics teachers with specific interest and training in graph theory, combinatorics and numerical analysis. This plan should apply to mathematics, as well as mathematicians, so that when we do gain some slack in our courses, discrete topics will receive preference over additional continuous topics. Although there appear to me to be some inherent pedagogical disadvantages to a unified discrete mathematics

course at the calculus level,* our existing courses could only be enriched by the inclusion of discrete methods. In many cases the machinery is already in place. Here are a few simple ways in which we could accommodate at least the spirit of discrete mathematics.

1. Use powerful, pervasive tools such as the computer, the Pigeon Hole Principle and systematic case exhaustion wherever possible and appropriate.
2. Return simple counting and probability to college algebra courses from where they disappeared in the not too distant past.
3. When the function concept is introduced in algebra, illustrate that domains don't have to be intervals. Use real examples, not contrived ones.
4. Don't skip the linear programming section in the precalculus book. Even though the Simplex Algorithm can't be fully explained here, require students to set-up linear programming problems and use canned software to crunch the numbers.
5. Numericalize (once in a while anyway). De-emphasize the classical theory of polynomial equations in favor of elementary approximate root searches. Emphasize setting-up Riemann Sums. Pay attention to error estimates.

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* Not many students study mathematics because they really want to. Most students take a maximum of one year of mathematics beyond preliminary algebra. (There are some obvious exceptions, of course.) We do these students a disservice, if we totally ignore mathematics' discrete component throughout this year (just as we would, if we totally ignored its continuous component). Nevertheless, calculus enjoys features that make it an almost perfect mathematical vehicle for students at this level, and, thus, difficult for mathematics educators to let go of. (1) Calculus is intrinsically visual and dynamic. (2) The limit concept is a singularly compelling unifier. Does discrete mathematics possess aspects powerful enough to rival these and support a yearlong course at the freshman/sophomore level? My concern is that no matter how interesting and pertinent discrete problems are or how easy they are to state, counting, in all its conceptual simplicity, is still distractingly hard. I'm afraid that of the three principal aspects of combinatorial reasoning (systematic analysis of possibilities, exploration of logical structure of a problem, and ingenuity) that Alan Tucker lists in his preface to [9], the third one, INGENUITY, will weigh far more heavily on students at this level than the first two, which are more coachable. And it is not clear what we can do beyond the intermediate algebra level to prepare students specifically for such a course.

6. Pay sequences (including recursively defined ones) their just due in calculus. (If you must, here's a better place to worry about convergence proofs.)
7. Spend less time on special techniques for finding closed-form solutions to first order differential equations, and gain an opportunity to investigate finite difference equations.
8. Be sure to use Markov chains as an example in linear algebra.
9. Continue to provide a finite mathematics alternative for appropriate majors.

MATHEMATICS AND LIBERAL ARTS

Facility with intermediate algebra is not an unreasonable thing to expect of all bachelor's degree aspirants. Beyond that, even students whose majors hold no apparent applications of mathematics should be exposed to some college level mathematics. Why? Because it's good for them. Some of us still believe, despite the trend toward specialization, that those who study a little mathematics (along with the other liberal arts) are somehow (perhaps intangibly) better off than if they had not studied mathematics at all. (See [3] for a clear and amusing statement of an opposite point of view.) Specifically, requirements for this audience ought to include statistics and either a mathematics appreciation course [2] or one of the conventional college level courses (college algebra, finite math, calculus). Unfortunately, appreciation-type mathematics courses have often attained popularity as nonchallenging alternatives to greater evils. These courses have underestimated their audiences by concentrating on mathematical fun-and-games or consumer mathematics; or they have completely missed their marks by attempting deadly snatches at abstract structures. The real heart of mathematics appreciation courses should be a few "grabber" ideas, preferably in the form of applications/problems [8], around which two-week units could be built. The mathematical potential of foci such as exponential growth and decay and Leontief input-output analysis is obvious; and numerous excellent UMAP Modules are tailor-made for this forum.

Certain items do not appear explicitly in any mathematics curriculum, yet their effect on how well our students learn is so fundamental that they warrant broad attention in mathematics courses.

For example, the making of lists and tables of data may seem simple and artless to us, but actually requires nurturing. Organization of data/information, as an incipient part of problem solving strategy [7], hardly needs elaboration here, but it does deserve magnification in our introductory classes. The ability to organize data skillfully can also be a significant ingredient in clear communication, which (I'm slightly reluctant to admit) is not the province of English and speech departments alone [5]. Mathematics' part in a "communication across the curriculum" effort need not be overly ambitious. If we only succeed in convincing our students that scientists believe lucid writing and speaking are important and that we are serious about promoting them, then we will have taken a step in the right direction. Incorporating brief writing exercises in tests and assignments should not prove too painful; and insisting that students compose their classroom questions precisely in complete sentences should require just patience and a little direction from us. Understand that mathematics must remain the guiding objective. Therefore, any contribution to the communications enterprise will necessarily be a selfish one, for careless use of language can only hinder productive thinking (about mathematics). Furthermore, we're all well aware of how much an explainer learns in trying to clarify an idea or problem for someone else. Why don't we exploit this phenomena?

CONTINUING EDUCATION

Maintenance of established quality and effective curriculum revision must come from an informed faculty, not imposed upon them. Community college administrations have not been notoriously supportive of faculty professional development except on a limited local scale. (Some have even been accused of fostering anit-intellectual environments.) Therefore, community college mathematicians need to make special efforts to keep up-to-date by reading journals, solving problems, attending professional meetings and enrolling in classes. Our national mathematics organizations must continue to recognize their two-year college constituency by sponsoring appropriate minicourses, publications, etc. Administrations must be convinced of the benefits to their institutions of funding rich sabbatical leave programs, faculty travel to national conferences, personnel exchanges with industry and

unlimited faculty access to new technologies such as microcomputers, word processors, video discs, etc. In the absence of these efforts changes in the curriculum will be cosmetic at best; with them it will evolve naturally and meaningfully.

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